EFFECT OF GRANULAR STRUCTURE ON THE ELECTRON FIELD EMISSION PROPERTIES OF NANODIAMOND FILMS

Hsiu-Fung Cheng

Department of Physics, National Taiwan Normal University, Taiwan 106, R.O.C.

Yen-Chih Lee, Su-Jien Lin

Department of Materials Science and Engineering, National Tsing-Hua University, Hsinchu, Taiwan 300, R.O.C.

I-Nan Lin

Department of Physics, Tamkang University, Tamsui, Taiwan 251, R.O.C.

Abstract

Diamond films have attracted considerable scientific attention as electron field emission materials due to hardness to withstand ion bombardment, and good thermal and electrical conductivity to handle high current[1-2]. Another advantage of diamond films, in term of field emission applications, is that these films can be synthesized easily by using microwave plasma enhanced chemical vapor deposition (MPECVD) process with consistent electron field emission properties. To further improve the electron field emission capacity of diamond films, reducing the grain size for the diamond films so as to increase the proportion of grain boundary region is required, as it has been proposed that the grain boundaries contain sp^2-bond[3] and provide conduction path for electron, facilitating the electron field emission process. In this present work, we adopted the bias enhanced technique for promoting the nucleation of nano-diamonds and suppressing the growth of grains. The electron field emission behavior of the nanodiamond films was observed to be pronouncedly superior to that of the diamond films with micron- or submicron-sized grains, which is ascribed to the presence of abundant grains boundaries with sp^2-bonds. Incorporation of boron species into the nanodiamond films further improves the electron field emission properties for the films. The best electron field emission properties achieved are turn-on field E_0=18 V/μm with electron field emission capacity J=0.7 mA/cm^2 at around 30 V/μm applied field. However, boron doping into the nanodiamond films does not result in consistent boron-content dependence of the electron field emission properties for the films as those in conventional micron-sized diamonds. The complication is explained by the fact that the small size of the diamond grains (~ 20 nm) may not be able to accommodate the boron species into the lattices to effectively act as acceptor dopants. Moreover, the formation of aggregates of the nano-sized diamond grains may alter the local field enhancement factor, which further complicates the correlation of the field emission behavior with the boron doping concentration for the nanodiamond films.

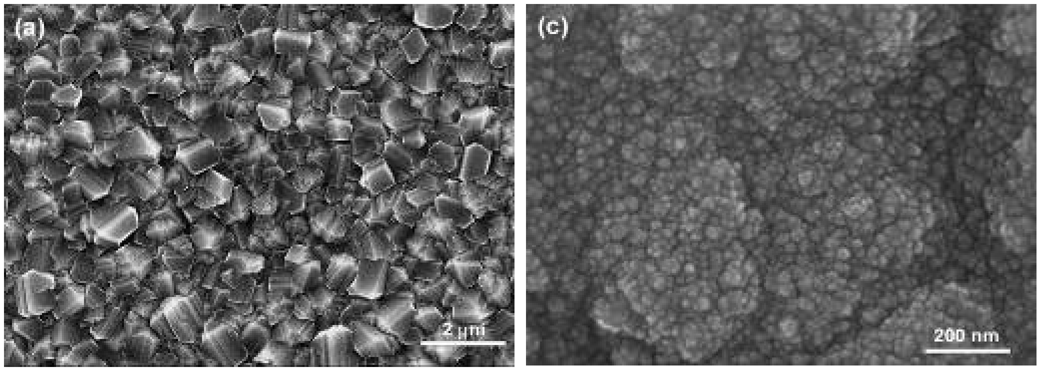

Fig. 1 SEM microstructure for the diamond films with (a) micron-sized grains and (c) nano-sized grains.

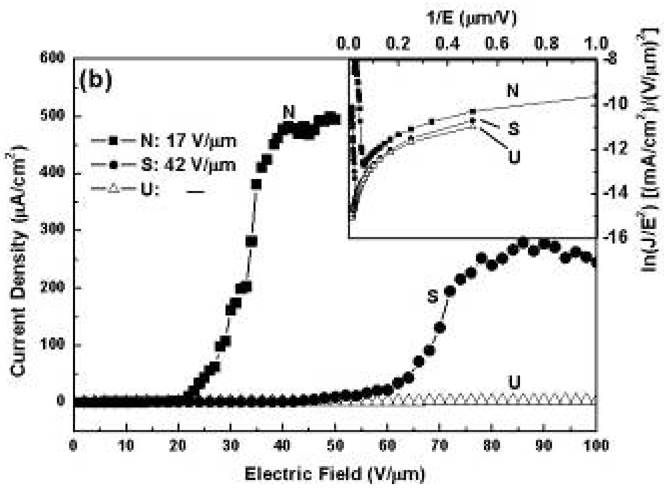

Fig. 2 The electron field emission properties for the diamond films with micron-sized grains (U), submicron-sized grains (S) and nano-sized grains (N).

REFERENCES

1. C.A. Spindt, I. Brodie, C. E. Holland, P. R. Schwoebel, in Vacuum Microelectronics, Wiley, 105 (2001); “Spindt Field Emitter Arrays”.
2. W. Zhu, P. K. Baumann, C. A. Bower, in Vacuum Microelectronics, Wiley, 247 (2001); “Novel Cold Cathode Materials”.
3. D. M. Gruen, Rev. Mater. Sci. 29, 211 (1999).